THE ENCYCLOPÆDIA BRITANNICA

The Encyclopædia Britannica. Ninth Edition. Vols. x. and xi. (Edinburgh: A. and C. Black.)

THESE two volumes of the *Encyclopædia Britannica* fully sustain the high character of the earlier volumes. The articles dealing with branches of physical and natural science are conspicuous by their high quality and number. In geographical science this volume is particularly strong. Dr. Rae contributes an article on "Greece," several specialists contribute the article on "Germany," and General Strachey of the Indian Civil Service has produced a very striking and valuable essay on the "Himalayas." Besides these there are shorter articles on "Greenland," "Grisons," "Guiana," the "Hawaiian Islands," and "Heligoland," all worthy of attention and replete with information. In medical science we note particularly the articles on "Gout," contributed by Dr. Affleck, and on "Heart Diseases" by Dr. G. W. Balfour. In the department of natural history the articles are almost exclusively on subjects of a specific or technical character; Prof. Newton writes on "Grouse," and Mr. John Gibson on the "Hare" and the "Hippopotamus." Prof. Church contributes brief articles on "Hemp" and "Guano," and Dr. Trimen has a good descriptive paper on "Grasses." The article "Herbarium," contributed by Mr. E. M. Holmes, is a remarkably useful and practical handling of a subject on which most botanical writers have usually very little to say; and the summary of information as to the character of the principal herbaria in existence will be found acceptable for reference. The contributions to the physical sciences are numerous and of great interest. Dr. Ball's article on "Gravitation" is at once simple and masterly. The article on "Harmonic Analysis" by the late Prof. Clerk Maxwell is all too short, but admirable in its way. Amongst technical subjects we may single out the articles on "Gunpowder" and "Gun-cotton" by Major Wardell and Prof. Abel respectively, on "Heating" by Capt. D. Galton, two long and very fully illustrated papers by Col. Maitland on "Gunmaking" and "Gunnery," and one on "Harbours" by Mr. T. Stevenson, which is accompanied by several capital plates. Mr. J. Blyth contributes two valuable articles on the "Gyroscope" and on "Graduation." From the latter we miss one or two points that might well have been added. There is no account of the dividing-machine employed by Messrs. Cooke and Sons of York in graduating the circles of the great Newall telescope; nor of the still more recent dividing engine constructed by the Waltham Watch Company. The biographical articles are numerous and excellent. Those on the two "Herschels" are from the pen of Prof. Pritchard. That on "Sir W. Hamilton" is contributed by Miss E. Hamilton. The biographical notice of "Sir W. Rowan Hamilton" is by Prof. Tait, than whom no one is more competent to write of the great mathematician; though somehow we miss in this thoughtful and appreciative article the peculiar characteristics of Prof. Tait's trenchant style. We propose to notice at greater length the important articles on "Geometry," "Geology," and "Heat."

The editor did well, we think, when he intrusted the compilation of the article upon such an important subject as "Pure Geometry" to so accomplished a geometer as Prof. Henrici. We can fancy what such an article would have been in the hands of the generality of English mathematicians trained at our conservative Universities, meek followers, for the most part, of one master: "There is but one Geometry, and Euclid is its exponent." We ourselves entertain a very high regard for Euclid: indeed our indebtedness to him for what ability we may have in geometrical science is as great as that of Cicero to Archias for eloquence; but we cannot help feeling that we might have had a far greater mastery over modern methods had our masters been acquainted with these methods themselves. "This book," says one who has recently left us, a consummate master of modern methods, "has been for nearly twenty-two centuries the encouragement and guide of scientific thought. . . . The encouragement, for it contained a body of knowledge that was really known and could be relied on, and that, moreover, was growing in extent and application. . . . the guide, for the aim of every scientific student of every subject was to bring his knowledge of that subject into a form as perfect as that which geometry had attained." In our author we have one who,

> "Nullius addictus jurare in verba magistri,"

can ungrudgingly acknowledge the many good points of the old-world geometer, whilst, with keen-cutting scalpel, he boldly lays bare his numerous defects. The present generation, perhaps, will not see Euclid superseded in our schools; but when his warmest defender makes him admit that his proofs might be abridged and improved, that alternative proofs may with advantage be appended to his, and that new problems and theorems might be interpolated, we may expect that a time will come, quickly if only the Universities would not handicap their favourite so heavily, when his order and numbering of propositions may be abolished, and his treatment of parallels shelved. In the meanwhile we must work in hope, and the article under notice will possibly pave the way for an improved mode of studying the science. As is well known, Prof. Henrici has long been engaged in writing a Geometry: to this work we must refer readers for his views on the subject. In the *book* we see him as the teacher, laying his foundations deep and strong and broad enough for the vast superstructure—all pure geometry—they have to bear: in the *article*, he treats his subject at first rather as the historian and critic, though subsequently he takes up the *rôle* of teacher again ("use doth breed such a habit in a man"), and rapidly but most deftly sketches a beautiful outline—in parts filled in—of the "higher" geometry. In a long, but far from tedious, sketch of sixty-four columns he treats pure geometry in two sections: the first, in twenty-five and a half columns, gives an account of the Elementary, or Euclidian, Geometry: the second is devoted to the Higher, or Projective, Geometry. In section I we have a running commentary on Euclid's text, which does at greater length, though somewhat in the same style, what De Morgan did some years since in the "Companion to the British Almanac" (1849). The axioms which lie at the basis of the subject are well discussed, and their foundation upon experience established: it is pointed out that the connection between these axioms has only been shown "within the last twenty years through the researches of Riemann and Helmholtz, although Grassmann had already published, in 1844, his classical but long-neglected 'Ausdehnungslehre.'" In this connexion we can merely refer to the admirable lecture by Clifford, "The Postulates of the Science of Space." There is a good statement of Euclid's assumptions, but we shall refer only to that which is made in I. 4, thus enunciated by De Morgan: "Any figure may be removed from place to place without alteration of form, and a plane figure may be turned round on the plane." This is employed by Prof. Henrici, as it has been by many others, to prove I. 5, with this difference, that he does it after Mr. Dodgson has made Euclid say there is "too much of the Irish Bull about it, and that it reminds one too vividly of the man who walked down his own throat, to deserve a place in a strictly philosophical treatise." But the difference between these two writers is a radical one, and is not confined to the above solitary instance. The treatment of Book I. (the remarks on axiom xii. in connection with I. 28, 29 are valuable) calls for no special comment. In Book II. we have the propositions discussed symbolically and proved by the aid of laws investigated by Sir W. Rowan Hamilton and Grassmann: laws familiar to more advanced students, but which are here put in a manner within the grasp, we think, of junior students. The book is one, however, to which this class never take very kindly, and requires patience and illustration on the part of the teacher. We can, from the outline here given, guess how Prof. Henrici will treat this part of geometry in his forthcoming second volume. The remarks upon the Fourth Book conclude with a "few theorems not given by Euclid," but they are readily derived from (if not explicitly stated in) Euclid's constructions. Of Book V. there is a careful sketch, and our author shows "Why the usual algebraical treatment of proportion is not really sound." (Here we may refer also to Mr. A. J. Ellis's "Euclid's Conception of Ratio and Proportion" in his "Algebra identified with Geometry," and in a simpler form in a lecture at the College of Preceptors.) Books VI., XI., XII. need not delay us. We come now to the Projective Geometry, which we should much like to see reproduced in pamphlet form for use in colleges or schools. We notice Prof. Henrici states, "In Euclid's *Elements* almost all propositions refer to the *magnitude* of lines, angles, areas, or volumes, and therefore to measurement." This, too, is our own view, and we presume it is what Mr. Wilson intended when he says: "Every theorem may be shown to be a means of indirectly measuring some magnitude"; whether it be so or not, at any rate Mr. Dodgson cannot impugn the Professor's more guarded statement. Those properties of figures which do not alter by projection are projective properties: there is a slight omission in the illustrations given, an exception should, we think, have been made in the case when the plane of projection is perpendicular to the plane upon which the quadrilateral, or circle, or other figure is projected. The points of difference between the two sciences are well put. "In Euclid each proposition stands by itself; its connection with others is never indicated; the leading ideas contained in its proof are not stated; general principles do not exist. In the modern methods, on the other hand, the greatest importance is attached to the leading thoughts which pervade the whole; and general principles, which bring whole groups of theorems under one aspect, are given rather than separate propositions. The whole tendency is to generalisation." Euclid, it is open to remark, throughout his work, avoids the *infinite*, whereas the modern geometry, like a good Samaritan, takes the most tender care of it. The systems adopted by Prof. Henrici are principally the methods of projection and correspondence—as handled by Von Staudt in the "Geometrie der Lage," and by Grassman in his above-cited work. We should like to analyse this sketch in detail, but we must forbear. For curves of two dimensions it is quite too delicious for us to mar it by such scant and imperfect treatment as we could here give it, and we must content ourselves with giving the heads of the several sub-sections. After the statement of definitions and preliminary explanations, we have segments of a line, projection and cross-ratios (Clifford's name for the anharmonic ratios of Chasles), correspondence, curves and cones of second order or second class, pole and polar, diameters and axes of conics, involution, involution determined by a conic on a line—foci, pencil of conics. The conclusion of the essay on the conics is that we arrive at the definitions from which our English text-books usually start. So the mode of treatment will be seen to be novel to the majority of English students. The concluding sections (six columns) on ruled quadric surfaces, but more especially on twisted cubics, seem to us to bear on their faces tokens of having been somewhat hurriedly written, so are not quite up to the high standard of the previous work. At the close Prof. Henrici refers his readers to Reye's "Geometrie der Lage" for "a more exhaustive treatment of the subject." "Scarcely any use has been made of algebra, and it would have been even possible to avoid this little, as is done by Reye." Prof. Clerk Maxwell, in a note to us, commended, in his own quaint way, this work of Reye. A short list of references is appended.

We could have wished that the "Analytical Geometry" had also been intrusted to Prof. Henrici, more especially that we might have seen how he would have connected the two together, and also that we might have had the subject discussed from a Continental point of view. We have sufficiently comprehensive and good treatises already by English writers, some of which are adorned with much of Prof. Cayley's work, and we feel, too, that had our author had *carte blanche* for space, he would have done his work well; whereas in attempting to pack much matter into a small space we think he has assumed much which is not familiar to some, and yet at the same time which is elementary to others who are advanced students. Nor does the article, to our mind, thoroughly serve for purposes of reference, though, no doubt, it goes some way to this end. The secret may be that "Pure Geometry" is more limited in its range, has, on one side, to do with a book known to almost all, and, on the other side, even does not reach, for the generality, beyond the conic sections; "Analytical Geometry," on the other hand, has to do with everything that relates to curves and surfaces, of whatever sort they may be. Prof. Cayley takes the line of analytical geometry "as a method," and confines himself, in his twenty-four and a half columns, to the consideration of the applications of Cartesian co-ordinates almost exclusively. The article is divided into the two sections of plane and solid geometry. At the commencement the student is recommended by the weight of Prof. Cayley's advice to trace a number of curves, and he draws a few simple ones, so drawing attention to a point upon which Mr. Frost, in his "Curve-Tracing," strongly insists. Prof. Clifford, too, we believe, had it in his mind to publish an account of some methods which "are exceedingly simple and easy of application; they partake more of the nature of a manual craft than of a purely intellectual occupation, and may so be used as a rest from severer studies; and, as we can only imagine things of which we have seen the like by appealing directly to the senses, they extend those powers of concrete realisation which the growing complication of modern analysis renders daily more desirable." The methods he alluded to are "Projection, a process by which no alteration is made in the order, the class, nor in any other purely descriptive property of a curve;" then "those modifications of form which leave the *order* of a curve unaltered;" then "those changes which exercise no effect upon the class." In the last two cases he proposed to use a process which he used to call "the *composition of curves*, by which a curve of any order or class may be built up out of the simplest elements." We fear that we have lost this proposed sketch, with the many other sketches he had outlined and lived not long enough to endue with a vitality he could so well have given them. After the illustrations referred to Prof. Cayley discusses shortly the metrical theory, and obtains the several familiar equations both in plane and solid geometry. In short paragraphs polar, trilinear, point, and line co-ordinates are described, but not applied. We have noted scarcely any misprints in the first article, but in the second there are several, all of which are easily detected. The figures are very well done.

We would draw attention to the article on Geodesy by Col. Clarke, which we have read with much pleasure. It is well illustrated, and the eighteen columns treat of the following matters:—Horizontal angles, astronomical observations, calculation of triangulation, irregularities of the earth's surface, altitudes, longitude. These are as fully discussed as need be in a sketch of the subject, and we shall expect that Col. Clarke's more extended work on Geodesy, referred to in NATURE, vol. xxi. p. 423, will take its place as a standard work for some time to come.

Geology occupies at the present day so important a position in the circle of the sciences that it deserves to be treated, in any modern cyclopædia, with no niggard hand. A slender essay, confined to a survey of the broad features of geology, would have been sadly disappointing in such a work as the "Encyclopædia Britannica." It is therefore satisfactory to observe that Prof. Geikie, to whom the editor entrusted this article, has put a liberal interpretation upon his trust. He has treated his subject with a fulness worthy of a great and growing science, and worthy too of the noble plan upon which the Encyclopædia has been projected. The masterly article which he has contributed to the new edition stretches over more than 320 columns, and is thus longer than most of the kindred articles, such as those on "Astronomy" and "Chemistry." Possibly it might have borne, here and there, a little condensation, but on the whole it is admirably fitted for its place. It stands forth as a solid and comprehensive monograph which, if reprinted from the Cyclopædia, would form one of the most substantial treatises in our geological literature. But the article is not only substantial, it is, like all Prof. Geikie's writings, eminently readable. The cardina virtues of an encyclopædist are accuracy and conciseness of expression, and he usually finds but little scope for the play of literary graces. Prof. Geikie, however, is far too polished an author to write upon any subject in an unattractive style; and the present article is sufficient to prove—were proof needed—that his graceful pen does not fail him, even when discoursing on the knottiest point in geology. The comprehensive nature of this article, and the originality with which the subject is treated, may be best shown by explaining the seven-fold division adopted by the author. First he deals with the *Cosmical Aspects of Geology*, and not only discusses the shape and the motions of the earth, but stretches his survey to the probable history of the solar system. Then he inquires into the nature of the materials of the earth's substance—an inquiry which falls under the head of *Geognosy*. In the early part of the article the author may seem to trench a little upon subjects which are treated in other articles, but this is almost inevitable in any cyclopædia. It is not to be expected that the several essays shall just touch each other without overlap, like the pieces of a neatly-jointed mosaic. The geognostic division of the article is followed by a section on *Dynamical Geology*, and this in turn by one on *Structural Geology*, or the architecture of the earth. Under the head of *Palæontological Geology* Prof. Geikie sketches the history of life as revealed by the fossiliferous deposits, while in the following section on *Stratigraphical Geology* he traces the chronological succession of events in the history of the stratified rocks. Finally a chapter is devoted to *Physiographical Geology*, or a discussion of the origin of the physical features of the earth's surface.

To see for the first time a great actor play the part of a familiar character is a treat; but the pleasure is seldom quite free from a mixture of disappointment. His reading of the part is usually not our pet and peculiar one, and we are, as it were, bullied into contentment by the great power of the performer. We felt something akin to it when we read the article "Heat" by Sir William Thomson, though the feeling was of course unreasonable. It often happens when for the second time we see a great actor play a great part we yield ourselves to his charm without a trace of intellectual reserve; so it will most likely be when next we read the article "Heat." At all events, the readers of NATURE may be assured that there is little in this article that they can justly find fault with, whatever they may miss to find that they expected. Could it be otherwise, when the author is the pupil of Regnault, the colleague of Joule, one of the patriarchs of the modern science of thermodynamics, the greatest living authority on the theory of heat in Britain? We shall therefore most modestly discharge our function by pointing out to our readers what they will find in Sir William Thomson's article; and by slightly indicating some points on which, to our regret, he has withheld his opinion.

The article opens with a discussion of the sense of heat, and of the distinction between heat and temperature. We are thus introduced to the conception of latent heat, which is explained at some length. The two leading methods of calorimetry, viz. calorimetry by latent heat, and thermometric calorimetry, are then discussed in general terms; and the results of the comparison of the different calorimetric units by Regnault and others are given. Then follows a full account of the origin of the modern theory of heat, which regards it as energy, and measures it by the equivalent amount of work. We thus have a third method of calorimetry, which is called dynamical calorimetry. Of the thirty-five pages occupied by the whole article eighteen are devoted to thermometry. This is the most important, and certainly the most interesting part of the article. After discussing a theoretical (and to some extent practical) system of thermometry by mixtures of hot and cold water, the thermoscope being the sense of heat in the hand, the author gives an elaborate classification of the different possible kinds of thermoscopes. Then comes an extremely interesting discussion of the merits of the different kinds of thermometers with arbitrary scales. The defects of the mercury-in-glass thermometer, and the advantages which led Regnault to prefer the (constant volume) air-thermometer are fully explained. We do not remember to have anywhere seen so full, and, it is needless to say, so philosophical an account of Regnault's results of the comparison of the different thermometric scales. The rest of the part devoted to thermometry is more or less speculative. The absolute thermodynamic scale of temperature, invented by the author himself, is defined; and its great advantage pointed out, viz., that it gives us a definition of temperature "such that, if a thermometer were graduated according to it from observation of one class of thermal effects in any one particular substance, it would agree with a thermometer graduated according to the same thermodynamic law from the same class of effects in any other substance."

Thermodynamic formulæ are investigated in a variety of cases for graduating thermometers, according to the absolute scale, from experimental data concerning the thermometric substance. A number of instruments are described in detail which are intended to realise these cases in practice. We are thus introduced to the water steam, mercury steam, and sulphurous acid steam thermometers, and the constant pressure hydrogen thermometer. These instruments are mostly new as to their details, and all of them are new in the sense that they have not been practically used hitherto. Nevertheless a great future is predicted for them. It would appear that Sir William Thomson has himself constructed models of them all; but whether he has used any of them in practical work he does not say. It has doubtless occurred to many of our readers, as it has to us, to have doubts and difficulties about thermometric measurements. Nowhere could we find better reasons for our scepticism than in the earlier part of Sir William Thomson's discussion of the systems of thermometry at present in use; we shall look, therefore, with all the greater interest for some farther account of the practical working of these new instruments. Their success, were it even but partial, would be an immense gain to thermal science. Thermal capacity and specific heat are next defined; and a brief account of the leading features of the results of different experimenters is given, without detail as to the methods employed in obtaining them. For further information we are referred to the articles on "Thermodynamics," "Matter," "Liquid," "Steam." The remaining five pages of the article deal with the transference of heat. Radiation is explained and distinguished from other modes of transference; but to our great regret is dismissed very briefly. A criticism of the work of the various experimenters in this department from an authority like Sir William Thomson would have been most interesting. There is still much doubt and difficulty hanging over the subject of the diathermancy of gases, for instance; we need scarcely mention as an illustration the famous controversy which has raged over water vapour. It may be however that these and kindred matters are to be treated under "Radiation" or "Light"; although we are not referred to these articles. The general principles of the theory of the conduction or diffusion of heat, as laid down by Fourier, are explained; and a most interesting critical account is given of the earlier attempts to measure conductivity. The explanation of the causes of the failure of Clément and Péclet in measuring high conductivities, such as that of copper, is very instructive, and should be closely studied by those engaged in like researches. Of the methods in use for measuring the thermal conductivity (or diffusivity as the case may be) of solids, Sir William Thomson prefers that of Angström, and recommends along with it the use of thermoelectric methods for determining the temperatures along the experimental bar. The mathematical theory of this method is given, and its connection with the researches of Forbes and Thomson on underground temperatures pointed out. The method of Forbes for measuring the conductivities of metals in absolute measure is described in general terms; and the results obtained with it by Tait are given, and compared with those of Ångström and Thalèn. We regret that no mention is made of the recent attempts to measure the conductivities of liquids and gases. The only result given is that of Bottomley for water, and no description of the method accompanies it. It is quite true that the success of many of these attempts has been somewhat doubtful; but, for that very reason, a criticism of the methods by a competent and impartial authority would have been most opportune, and useful as a guide to future experimenters. Appended to the article are a series of ten tables of thermal constants, and a reasoned synopsis of the principal mathematical formulæ that occur in the theory of diffusion. This last is a most valuable part of the article; for it could be given only by a master of the subject, and it is likely to be extremely useful to many physicists, who have sufficient knowledge to enable them to use such formulæ, but not sufficient mathematical power to find them for themselves, or sufficient time to hunt them up from ponderous treatises and half-forgotten memoirs when they want them.

We sincerely congratulate the editor and publishers of the *Encyclopædia* on the high degree of success which continues to attend their great undertaking.

OUR BOOK SHELF

Life and Her Children: Glimpses of Animal Life from the Amœba to the Insects. By Arabella B. Buckley. (London: Edward Stanford, 1880.)

AFTER light came life, and with that life there came its two great functions—growth and development. With the simplest as with the most complex forms there is the same eager race to be run, to increase in size, to multiply, and thus replenishing this earth, to die. "Life and Her Children" is a praiseworthy and admirable attempt to tell us something of the Children that Life sends forth, and of their history. Its main object is to acquaint young people with the structure and habits of the lower forms of life; but in our deliberate judgment it will do a great deal more. None will read its introductory chapter without advantage, and few will read the volume through without enjoyment. Within its narrow limits of 300 small pages no candid reader would expect to find all the details that might be wished for, or all the illustrations that might be desired. What constitutes the book's chief charm is the marvellously simple yet quite scientific style which runs through it, the food for thought and future study which it affords, and the truly philosophic glow which lights up its every page. The volume gives a general account of Life's Simplest Children, the Protozoa. The word "slime" does not seem to us quite a happy term by which to designate the living protoplasm of these creatures; this word conveys the idea of a something adhesive or glutinous, or of a something thrown off a living organism—a something without a structure (sordies, eluvies)—and there seems somewhat of a "contempt for nature," a thought certainly never present in the author's mind, in the use of such a word. Jelly would seem a more appropriate word, as conveying the idea of the consistency requisite for life, and would have the sanction of use. Thus the Noctilucæ, called in this volume "tiny bags of slime," were described, if we mistake not, by their discoverer as "tiny spherical gelatinous bodies," and Prof. Huxley says, "Noctiluca may be described as 'a gelatinous transparent body about the one-sixtieth of an inch in diameter.'"

The chapter on "How Star-fish Walk and Sea-Urchins Grow" is excellent. The story of how the five curious little oval jelly bodies swimming about by their jelly lashes in the depths of the smooth water in some English bay—ended in becoming respectively a lily star, a brittle star, a starfish, a sea-urchin, and a sea-cucumber, is well told, and woodcuts, though they make one see as in a glass darkly, help in their own way to make the meaning plain. In the "Outcasts of Animal Life" a difficult problem is treated of. It need not surprise one that it is not solved. The last four chapters tell of "the Snare-Weavers and their Hunting Relations (spiders)"; the Insects which change their coats but not their bodies, and those which remodel their bodies within cover of their coats; "the Intelligent Insects with Helpless Children, as illustrated by the Ants." This volume thus tells of the greater part of the living invertebrate animals as they are spread over the earth to fight the battle of life. "Though in many places the battle is fierce and each one must fight remorselessly for himself and his little ones, yet the struggle consists chiefly in all the members of the various brigades doing their work in life to the best of their power, so that all while they live may lead a healthy, active existence. The little bird is fighting his battle when he builds his nest and seeks food for his mate and his little ones; and though in doing this he must kill the worm, and may perhaps by and by fall a victim himself to the hungry hawk, yet the worm heeds nothing of its danger till its life comes to an end; and the bird trills his merry song after his breakfast, and enjoys his life without thinking of perils to come. So Life sends her Children forth; and it remains for us to learn something of their history. If we could but know it all, and the thousands of different ways in which the beings around us struggle and live, we should be overwhelmed with wonder. Even as it is, we may perhaps hope to gain such a glimpse of the labours of this great multitude as may lead us to wish to fight our own battle bravely and to work and strive and bear patiently, if only that we may be worthy to stand at the head of the vast family of Life's Children."

The work forms a charming introduction to the study of zoology—the science of living things—which we trust will find its way into many hands. E. P. W.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*]

The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.]

Prof. Tait and Mr. H. Spencer

As Mr. Spencer has already got the length of calling some of my statements "fictions, pure and absolute," it is time that this discussion should cease. But it is necessary that I should at least show my reasons for having made the statements in question. They will be found ample.

Mr. Spencer's pamphlet, which originated this discussion, and in which I am the first subject brought up for vivisection, bears on the title-page that it deals with *Criticisms*.

The only passages of mine which Mr. Spencer quotes, which can possibly have the slightest reference to himself, and which can in any way be construed into criticisms, are but two in number. In these, or in one of them, the cause of his attack on me must be sought.

The first is mainly a verbal transcription from Mr. Kirkman, and as such it is none of mine; but in introducing it I inadvertently (though correctly) spoke of the "Formula of Evolution" as a *definition*.

The second is a passage *from a different part* of my article on Sir E. Beckett's book, and its application is to materialists and agnostics in general.

This latter passage did not appear to me capable of having roused the vivisection-instincts of so calm a philosopher as Mr. Spencer, especially as it was not applied to any one in particular. Of course, then, I at once assumed that the former passage contained the offence which was to be expiated; and I was confirmed in this idea by the way in which Mr. Spencer put his *formula* alongside of the Law of Gravitation. I could not have ventured to suppose that Mr. Spencer "*did not even know that he was in the habit of saying formula rather than definition.*" This *naïve* confession cannot but be correct. Had it been made in Mr. Spencer's pamphlet, I should not have thought it necessary to say a word. It explains at once his frequent entire misapprehensions of my meaning. So I give up my plausible theory of the origin of Mr. Spencer's attack on me; and shall, henceforth, ascribe that attack to my having made a singularly apt and telling quotation from Shakespeare!

With regard to the other parts of the discussion, I feel that I need not add anything to what I have already said; except on one point, an important one.

Mr. Spencer has employed an old remark of Prof. Huxley as to what mathematics can, and cannot, do; but he has not employed it happily, for the question at issue is really this:—Is it correct to speak, at one time, of force as an agent which changes a body's state of rest or of motion, and again to speak of it as the time-rate at which momentum changes or as the space-rate at which energy is transformed?

I answer that there is not the slightest inconvenience here; except, perhaps, in the eyes of those metaphysicians (if there be any) who fancy they know *what* force *is*. Such phrases as "the wind blows," or "the sun rises," though used by the most accurate even of scientific writers, would otherwise (on account of their anthropomorphism) have to be regarded as absolute nonsense. P. G. TAIT